JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

MAIN

REGULAR

COURSE CODE: SPH 204

COURSE TITLE: Oscillations And Waves

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION:**

TIME: 2:00HRS

Instructions:

1. **This paper consists of FIVE Questions. Answer QUESTION ONE (COMPULSORY) and any other TWO Questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

QUESTION ONE (Compulsory) (30 Marks)

a. Define simple harmonic motion **(1 mark)**

b. The displacement *x* of a simple harmonic motion is given by $x = A\sin(\omega t + \phi)$
Show that the ratio of the displacement *x* to the velocity *v* of this motion is given by

$$\frac{x}{v} = \omega^{-1}\tan(\omega t + \phi)$$

(3 marks)

c. A uniform string has a mass M of 0.08 kg and a length L of 6.00 m. Tension is maintained in string by suspending a block of mass 6.0 kg on the free end. Find the speed of a transverse wave pulse on this string. **(2 marks)**

d. Show that the energy E, contained by a spring whose spring constant is *k* executing simple harmonic motion, is given by $E = \frac{1}{2}kA^2$ where *A* is the amplitude. **(4 marks)**

e. Derive the linear wave equation of the form $\frac{\partial^2 y}{\partial x^2} - \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2} = 0$ **(3 marks)**

f. Depending on the magnitude of the damping constant, there are three cases of damping namely **overdamping, underdamping and critical damping**. Analytically present the general equation of each case, physical interpretation and sketch their motion graphs on a single cartesian plane. **(6 marks)**

g. Derive the doppler effect equation with the constants having their usual meanings
i. **(6 marks)**

h. Show that the velocity of a longitudinal wave, e.g. sound, propagating in a fluid of density *p* and bulk modulus *B* is given by the equation

$$v = \sqrt{\frac{B}{\rho}}$$

(5 marks)

QUESTION TWO **(20 Marks)**

a. The position of a particle executing simple harmonic motion is given by $x = 1.25\sin(10t + 64)m$ where t is in second. Determine

i. the period and range of the motion **(3 marks)**

ii. the position, velocity and acceleration of the particle at t= 9sec **(6 marks)**

b. The equation of a mechanical wave is given by $y(x,t) = 1.5\sin\left[\frac{\pi}{2}(20x - 30t) - \frac{\pi}{8}\right]m$

Find i. The wavelength, the frequency and the velocity of the wave pulse **(3 marks)**

ii. The position, velocity and acceleration of the particle of the medium at *x=2m and t=4 seconds* **(6 marks)**

QUESTION THREE **(20 Marks)**

a. A wave that propagates along a string transports energy and transmits power. Show that the average power P_{av} transmitted by a wave of angular frequency ω and propagating at wave velocity v on a string of linear mass density μ is given by

$$P_{av} = \frac{1}{2}\mu(\omega A)^2 v$$ **(6 marks)**

b. A point mass *m* is freely suspended on a string of length *l* and given a displacement from horizontal so that it swings freely as an oscillating simple pendulum. Show that the period of oscillation is given by $T = 2\pi\sqrt{\frac{l}{g}}$ **(6 marks)**

c. When an object executing simple harmonic motion is subjected to energy losses, it undergoes damping.

i) Show that the general equation of a damped harmonic motion takes the form $\ddot{x} + 2\gamma\dot{x} + \omega^2 x = 0$ **(2 marks)**

ii) Evaluate the general solution of the damped harmonic equation above **(4 marks)**

QUESTION FOUR **(20 Marks)**

a. If a solid bar of aluminum 1.00 m long is struck at one end with a hammer, a longitudinal pulse propagates down the bar. Find the time it will take the pulse to travel from one end to the other if it has a Young's modulus of 7.0×10^{10} Pa and a density of 2.7×10^{3} kg/m^3. **(4 marks)**

b. i. Define Doppler effect **(2 marks)**

ii. An ambulance travels down a highway at a speed of 75.0 m/s, its siren emitting sound at a frequency of 400 Hz.

I. What frequency is heard by a stationary observer;

a) being approached by the ambulance

b) being left by the ambulance **(6 marks)**

II. What frequency is heard by a passenger in a car traveling at 55.0 m/s in the opposite direction as the car and ambulance

a) approach each other and

b) pass and move away from each other? Take the speed of sound in air to be 350m/s **(8 marks)**

QUESTION FIVE **(20 Marks)**

a. In an effort to get your name in the Guinness Book of World Records, you set out to build a bass viol with strings that have a length of 5.0 m between fixed points. One of the strings has a mass per unit length of 12g/m and a fundamental frequency of 20.0 Hz.

i. Calculate the tension in this string. **(2 marks)**

ii. Calculate the frequency and wavelength of the second harmonic. **(4marks)**

iii. Calculate the frequency and wavelength of the fourth overtone. **(4 marks)**

b. In the Taita community, flutes are played in celebrations of the newborns. A flute of length 80cm is always ideal for the occasion.
What are the wavelengths and frequencies of the first four harmonics that can be produced to entertain the newborn if the flute is (a) open, (b) closed? Take the speed of sound *v= 350m/*s. **(10 marks)**